CLOUDBRIDGE
NATURE RESERVE

Comparison of Avian Flight Initiation Distances at Trails within a Costa Rican Cloud Forest

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CLOUDBRIDGE NATURE RESERVE

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2 ABSTRACT

Cloudbridge Nature Reserve, lying adjacent to Chirripó National Park in southern Costa Rica, contains over 400 types of bird along with thousands of other different species of plants and animals. There are numerous trails within the reserve that are private and used only by staff and researchers, or are open to the public and have an additional recreational use. Cerro Chirripó in Chirripó National Park, the highest peak in Costa Rica at 3821 metres, is an extremely popular local attraction with hundreds of visitors hiking to the summit each year. A 1.5 kilometre section of this busy hiking trail borders the southern edge of Cloudbridge Nature Reserve and connects with the reserve´s trail network before carrying on to the summit. This not only provides an alternative route to the summit through the reserve, but also creates an extremely popular 8 kilometre hiking loop.

This study investigated what effect, if any, anthropogenic disturbance has on the flight initiation distance (FID) of birds along both public and private trails within and around Cloudbridge Nature Reserve. There has been no known previous local studies on this topic. In other parts of the tropics, hiking trails have been identified as having an adverse effect on bird behaviour with a possible detrimental effect on overall abundance (Alwis *et al.*, 2016). Six trails with varying degrees of anthropogenic use were chosen and FID was measured along each trail. The trail with the highest footfall, Chirripó, had the highest FID while one of the least-used trails, Gavilán, had the shortest FID. Slate-throated Redstart (*Myioborus miniatus*) had a significantly higher FID at the Chirripó trail, possibly due to sensitisation. When the average body lengths of species was compared between trails, it was found that trails with minimum disturbance had longer birds. Abundance and diversity were found, in general, to be negatively correlated, with busier trails having less species diversity but more abundance. It was concluded that further studies are warranted, particularly regarding the Slate-throated Redstart, and that investigating the effect of human disturbance on the behaviour of local mammals should also be considered.

3 INTRODUCTION

The numbers of tourists visiting Costa Rica each year has increased from 155,000 in 1970 to 1.1 million in 2000 (Jones & Spadafora, 2017) with many travelling to see the country's outstanding natural beauty, abundant wildlife and numerous national parks. Consequently, nature-based tourism and associated outdoor recreational activities, such as hiking, has increased dramatically, along with potential disturbance to local wildlife. Human disturbance can be defined as "any human activity that constitutes a stimulus sufficient to disrupt normal activities and/or distribution of animals relative to the situation in the absence of that activity" (Cardoni *et al.*, 2008). Cloudbridge Nature Reserve lies adjacent to Chirripó National Park in the Talamanca mountains and contains many trails that are used for recreational and/or research purposes. One of the most popular trails, the Chirripó trail, borders the southern edge of the reserve and is used by thousands of hikers annually to climb Cerro Chirripó, Costa Rica's tallest mountain. The trail is also used at least twice weekly by many porters and their horses to bring supplies to a café and hostel located further up the trail. The potential adverse effect of this anthropogenic disturbance to local bird behaviour has, to date, not been investigated and this project attempts to fill the research gap whilst providing baseline data to Cloudbridge Nature Reserve.

Anthropogenic disturbance has been shown to have considerable effect on bird behaviour around the world as birds expend valuable energy avoiding humans instead of utilising it for other behaviours such as foraging or breeding (Alwis *et al.*, 2016). New Zealand dotterels, an endangered, ground-nesting shorebird, flush from their nests and temporarily abandon their eggs when the nests are approached by a person, leaving eggs vulnerable to "increased predation and thermal stress" which may be a reason for low-hatching success (Lord *et al.*, 2000). Disturbance caused by hikers on recreational trails in Sinharaja World Heritage Forest in Sri Lanka resulted in certain bird species avoiding habitats at trail edges. Interestingly, some birds were more sensitive than others to human recreational disturbance, while others appeared to have become habituated to the disturbances (Alwis *et al.*, 2016). At the Tipperne Reserve in Denmark, Black-tailed Godwits (*Limosa limosa*) underwent "effective habitat loss by avoiding territory establishment in proximity to a source of human disturbance" (Holm & Laursen, 2009). Similarly, bird abundance, species richness and habitat use of waterbirds in Los Padres Lagoon Reserve in Argentina were all negatively affected by recreational activities (Cardoni, *et al.*, 2008). There has been no known investigation into what impact the recreational use of hiking trails has on avian responses in the cloud forests of Costa Rica. Indeed, a review of current knowledge on the impacts of nature-based recreation on birds, notes that research from Central America "is almost completely absent" and there "remains large research gaps on this topic" (Steven *et al.*, 2011). The cloud forest at Cloudbridge Nature Reserve contains many endemic species of birds, for example the Collared Redstart (*Myioborus torquatus*) and Black Guan (*Chamaepetes unicolor*), along with threatened bird species like the Resplendent Quetzal (*Pharomachrus mocinno*). As

a result, anthropogenic effects on bird behaviour at Cloudbridge can be deemed a significant conservation issue that warrants further investigation and analysis.

Flight Initiation Distance (FID) is the distance between the bird and an approaching threat when the bird takes flight, or in other words, is the point at which the cost of staying is greater than the cost of escaping (Braimoh *et al.*, 2018). It is widely used as a quantitative index for the tolerance of birds to human disturbance as, in general, FID increases as the level of assessed risk to the animal increases. This research project investigated the FID's of several bird species at various trails around Cloudbridge Nature Reserve to ascertain if the frequency of trail-use influences the distance at which a bird takes flight, thereby indicating negative anthropogenic impacts to the birds. It was hypothesised that there was a significant difference between the FID's of birds at high-use trails with the FID's of birds at trails with a lower level of use.

4 STUDY LOCATION

Research was carried out at Cloudbridge Nature Reserve, Costa Rica, approximately 09°50'N, 83°55'W. The reserve is roughly 280 hectares in size, lying between 1500 and 2800 metres in altitude on the Pacific side of the Talamanca Mountains, adjacent to Chirripó National Park. The reserve is a mixture of the following habitat types:

- Old growth forest (OG)
- Planted areas (P)
- Areas with both planted and naturally regenerated forest less than 30 years old (P/NR<30)
- Naturally regenerated forest areas less than 30 years old (NR<30)
- Naturally regenerated forest areas more than 30 years old (NR>30)
- Naturally regenerated areas with forest both more than and less than 30 years old (NR+/-30)

Due to the nature of this study, there were no fixed points for data collection as measurements were taken along six different trails in the reserve – Chirripó, Heliconia, Gavilán, Principal, Montaña, and Río – at an elevation range of between approximately 1600 metres and 2100 metres in altitude (Figure 1).

All surveys, except those at Chirripó, were carried out in planted or naturally regenerated forests of differing ages, or areas that were a mixture of both planted and naturally regenerated forests of differing ages. At Chirripó however, data was collected along a large stretch of the trail in both naturally regenerated and old growth forests.

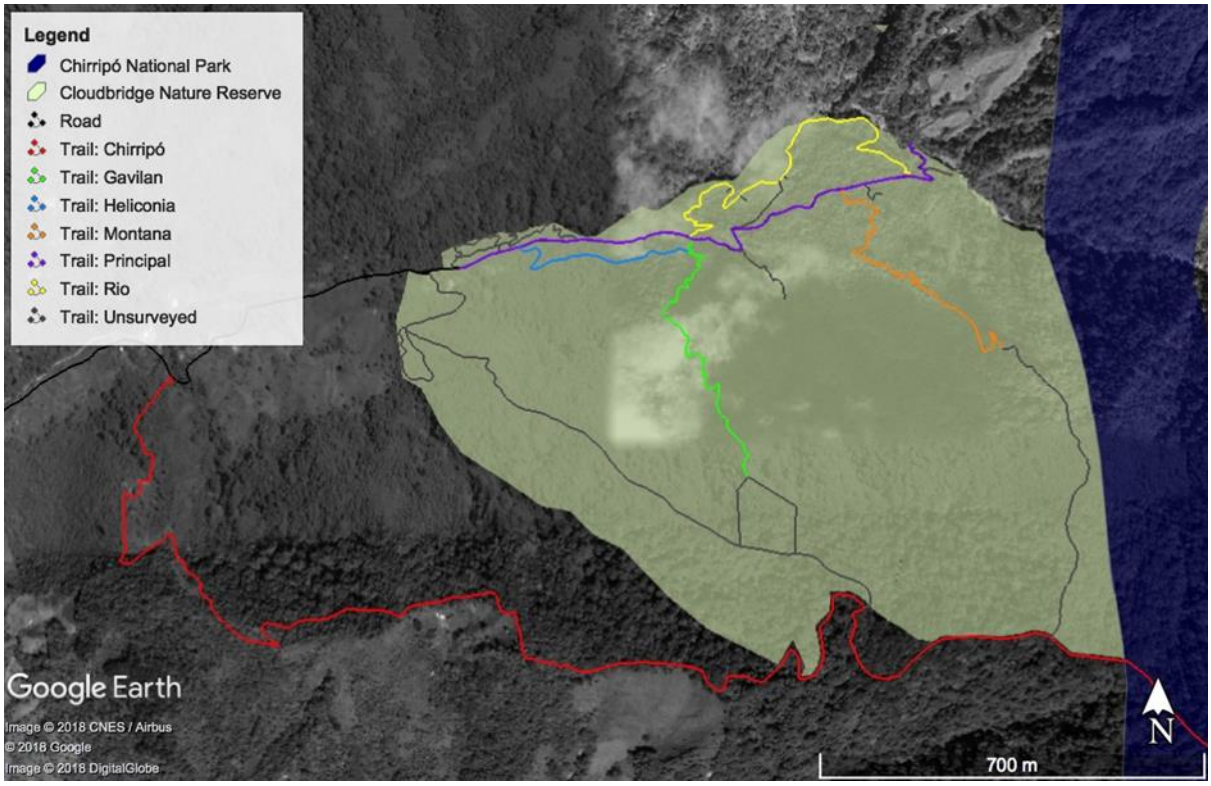

Figure 1. Map of the six trails surveyed within and around Cloudbridge Nature Reserve.

5 MATERIALS & METHODS

5.1 PRELIMINARY RESEARCH

Before raw data was collected, preliminary research was carried out from 9th to 19th May 2018, inclusive. During this time, the frequency with which the trails were used by recreationists, researchers and volunteers, as well as by porters with and without horses, was monitored and quantified and three trail categories were devised as shown in Table 1.

It was also ascertained during this preliminary period that old growth forest was generally not suitable for data collection due to difficulty in bird observation and identification in these areas. A section of the Chirripó trail was considered the exception to this generalisation due to the busy nature of the trail and its importance as a potential influence on local avian FID's.

Familiarisation with bird species was also carried out before raw data collection using two reference guides – Garrigues & Dean (2017) and Stiles & Skutch (1989).

Table 1. Categorisation of trails according to activity levels.

Trail	Use per day	Category
Chirripó	> 15 people/horses	High
Montana	5 - 15 people	Medium
Rió		
Principal		
Gavilan	< 5 people	Low
Heliconia		

5.2 SURVEY METHODS

Surveys were carried out from 21st May to 28th June 2018 inclusive, between 05.30 h and 10.30 h (CST), during times of peak bird activity. Six trails were surveyed – Chirripó, Gavilán, Heliconia, Montaña, Principal, and Río. Trails were surveyed in a random order and with varied frequency. The number of times each trail was surveyed is shown in Table 2.

Table 2. Number of surveys carried out at each trail.

Trail	No. Surveys Carried Out
Chirripó	5
Gavilán	8
Heliconia	8
Montaña	8
Principal	12
Río	7

Prior to commencement of each survey, the rain, wind, and cloud cover were noted in accordance with the classes listed in Appendix I. The date, start time, and end time were also recorded for each individual survey. To collect data, the surveyor walked along the trail at a steady pace remaining alert and watchful to the presence of birds. When a bird within eye-range was identified, the surveyor walked towards the bird until the bird took flight. The surveyor then stopped walking and measured the distance between themselves and the location the bird took flight from.

Birds were identified visually with the aid of Opticron Aspheric LE WP 8 x 25 field binoculars in addition to the Garrigues & Dean (2017) field guide. An Opti-Logic 400LH range finder was used to measure the flight initiation distance. To obtain the distance reading, the range button was pressed and, using the viewfinder, the red dot aiming aid was placed on the location at which the bird had initiated flight. Following the resulting

"beep", the distance was read from the external liquid-crystal display (LCD). The distance was measured in metres using the Mode 1 "Line-of-Sight Distance" setting. According to the manufacturer's instructions the accuracy of the range finder is +/- 1 yard (0.91 m) with a range resolution of 0.5 yard (0.46 m).

The duration of surveys was varied and not fixed throughout the research period. The surveyor walked at a steady pace to the halfway point specified in Table 3 and then either concluded the survey or returned back along the trail to the start point. All survey measurements and associated details (e.g. weather conditions) were recorded with pencil and written in a hardback field notebook.

Table 3. Positional coordinates of survey start and finish points, as well as elevation and habitat-type summaries.

Trail	Start/Finish		Half-way Point/Finish		Max Elevation	Min Elevation	Habitat Type
	Latitude	Longitude	Latitude	Longitude			
Chirripó	9.465606°	-83.585004°	9.464945°	-83.566082°	2123m	1659m	OG, NR+/-30
Montana	9.473632°	-83.569048°	9.469650°	-83.565838°	1974m	1722m	P/NR<30
Rió	9.474042°	-83.567664°	9.472651°	-83.572292°	1720m	1637m	P/NR<30
Principal	9.472071°	-83.575893°	9.474042°	-83.567664°	1726m	1607m	P/NR<30
Gavilan	9.472357°	-83.572393°	9.468772°	-83.571740°	1870m	1694m	P/NR<30, NR>30
Heliconia	9.472242°	-83.572061°	9.472098°	-83.575895°	1723m	1606m	P/NR<30

6 DATA ANALYSIS

All data was statistically analysed using SPSS statistics computer software. Data was tested for a normal distribution using a one-sample Kolmogorov-Smirnov test for goodness-of-fit. If necessary, data was either log10-transformed or square-root-transformed to achieve normal distributions. Total mean FID between each of the six trails was compared with a one-way analysis of variance (ANOVA) test. Three species were present at each trail and their mean FID was compared separately by species with a one-way ANOVA test. There was insufficient data to analyse species-level response for all species recorded. Mean body length for each trail was also analysed with a one-way ANOVA test. A one-way ANOVA compared the abundance of birds between trails.

A Simpson's Index of Diversity (SID) formula was used to calculate diversity at the trails. The following formula was used, where n is the total number of individuals of a species, and N is the total number of all individuals of all species:

Simpson's Index of Diversity = $1 - \Sigma n(n-1) / N(N-1)$

Several assumptions were made when collecting and analysing data. Firstly, it was assumed that every bird sampled was unique and there was no repetition of individuals. Secondly, the walking pace of the surveyor was assumed to be identical for each survey. Thirdly, it was assumed that the surveyor was competent in bird identification and each bird was correctly identified and named. It was also assumed that the distance of the bird from vegetation did not affect the FID. Finally, it was assumed that all measurements obtained by the Opti-Logic range finder were accurate and that vegetation or any other obstructions did not affect the range finder's measuring capacity.

7 RESULTS

From the 21st May to the 28th June, 2018, 48 individual surveys were carried out yielding 122 different measurements on 25 unique bird species. The raw data collected can be found in Appendix II and results in taxonomic order in Appendix III. The overall mean FID across all six trails was 7.66 metres (SD = 3.29).

Chirripó had the highest mean FID at 8.67 metres, with Río a close second at 8.34 metres. Gavilán had the shortest at 6.43 metres. Mean FID for all species did not differ significantly between trails when a one-way ANOVA test with $\log_{10}$-transformed data ($F_{5,116} = 1.32$, $p = 0.26$) was performed, Figure 2.

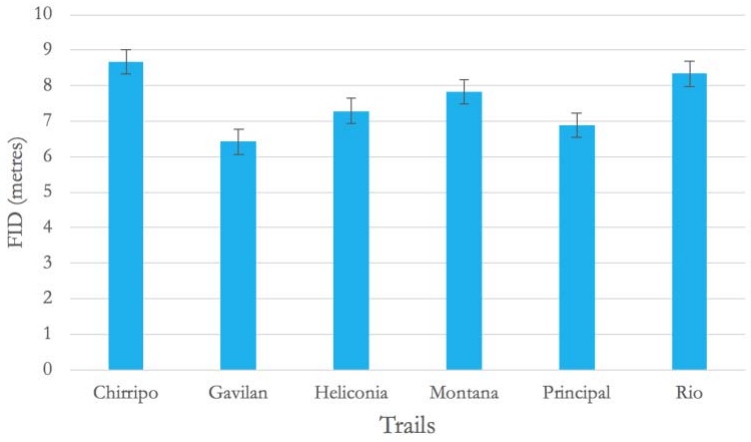

FIGURE 2. OVERALL MEAN FID FOR ALL SPECIES ON EACH OF THE SIX TRAILS.

The longest FID at 19.1 metres was observed in a Slate-throated Redstart (*Myioborus miniatus*) at Chirripó. The shortest was 3 metres from a Scintillant Hummingbird (*Selasphorus scintilla*) at Principal. Three species were observed at all six trails – Black Guan, Common Chlorospingus (*Chlorospingus flavopectus*) and Slate-throated Redstart. A one-way ANOVA between trails for the mean FID of the Black Guan was not significant ($F_{5,9} =$

0.5, p = 0.77). Similarly, there was no significance difference between trails for the mean FID of the Common Chlorospingus when a one-way ANOVA test using log_{10}-transformed data was used ($F_{5,17} = 0.4$, p = 0.84).

There was, however, a significant difference in the FID between trails for the Slate-throated Redstart ($F_{5,11} = 9.176$, $p < 0.01$) (Table 4).

For the Slate-throated Redstart, Chirripó returned a mean FID of 15.1 metres, while mean FID at other trails was significantly lower at between 9.5 and 5 metres (Figure 3).

Table 4. One-way ANOVA results for Slate-throated Redstart.

Source	d.f.	SS	MS	F	P
Trail	5	187.9	37.56	9.18	0.001
Residual (Error)	11	45.03	4.09		
Total	16	232.9	14.56		

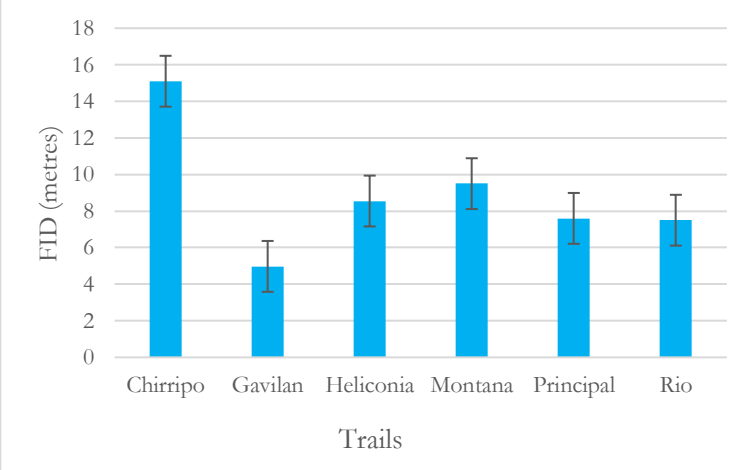

Figure 3. Mean FID of Slate-throated Redstart (*Myioborus miniatus*) at each trail.

Body lengths for all species were calculated using measurements cited in Stiles & Skutch (1989), resulting in a total mean body length of 21.8 cm (SD = 15.68). Black Guan was the longest species measuring 64 cm in length, while the smallest was the Scintillant Hummingbird at 6.5 cm. Mean combined FID for each trail was also calculated. The largest species were found at Heliconia with a mean body length of 24.75 cm. Montaña had the smallest birds at a mean body length of 20.38 cm, closely followed by Chirripó with 20.63 cm (Figure 4). A one-way ANOVA of mean body length between trails reported no significant difference ($F_{5,52} = 0.09$, p = 0.994).

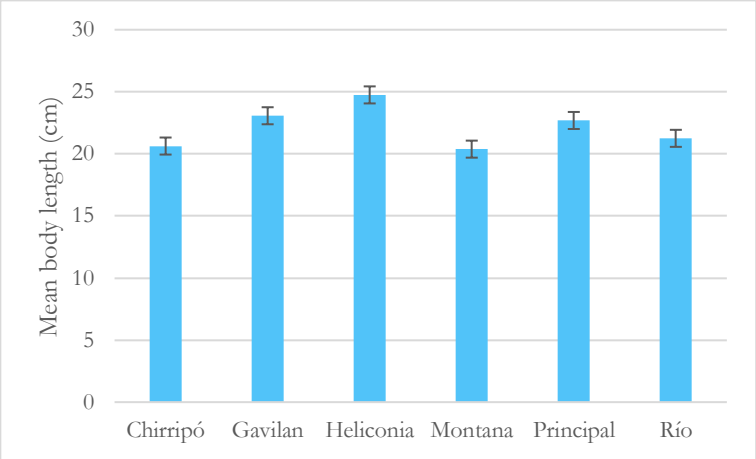

Figure 4. Mean body length (cm) for all species combined at each of the six trails.

Mean abundance of birds was 2.54 per trail (SD = 2.25). Chirripó reported the highest number per survey with a mean of 5 individuals, while Heliconia had the lowest with a mean of 1.75 birds recorded per survey (Figure 5). A one-way ANOVA of the square-root-transformed data between trails did not produce significant results ($F_{5,42} = 1.78$, $p = 0.14$).

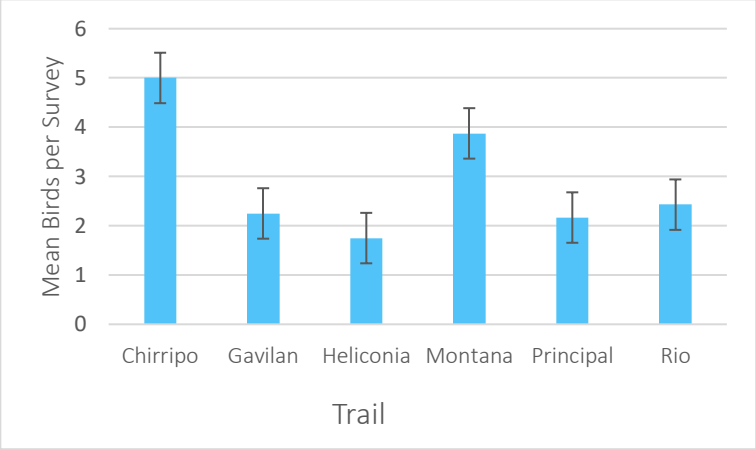

Figure 5. Mean number of birds observed per survey at each trail.

All trails yielded high levels of diversity using the Simpson's Index of Diversity (SID) with all six reporting values of more than 0.8. Highest levels of diversity were seen at Río and Principal while lowest were obtained at Chirripó and Gavilán (Figure 6).

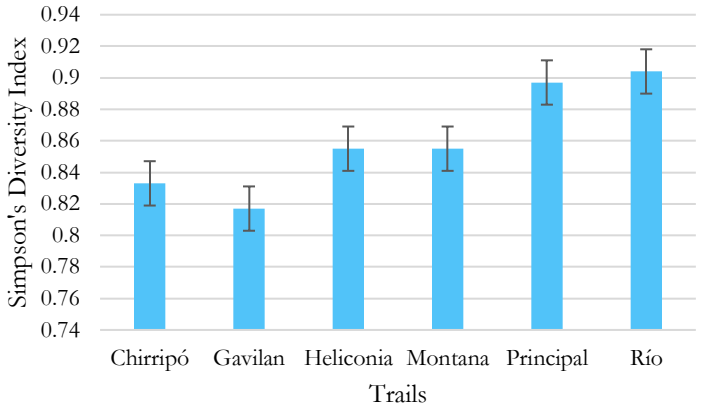

Figure 6. Simpson's Diversity Index results for each trail.

8 DISCUSSION

8.1 SENSITISATION AND HABITUATION

The distance at which an individual bird took flight when approached by a human differed considerably between species. There may be many reasons for this interspecific variation in FID such as differences in species' body size, diet, personality, physiology and breeding systems (Blumstein, 2006). Longer FID were reported from trails with higher levels of anthropogenic disturbance while those of lower levels of disturbance had the shortest. Alterations to the flight initiation behaviour of birds at trails usually occurs through one of two mechanisms – sensitisation (or facilitation), or habituation (Weston *et al.*, 2012). Habituation results in shorter FID and usually only occurs when the disturbance to the bird is "predictable or non-threatening" (Knight & Miller, 1996). Sensitisation sees the development of longer FID which indicates a reduced tolerance to disturbance and an increase in vigilance behaviour. It usually arises from "dangerous, irregular, rapid and unpredictable stimuli" (Weston *et al.*, 2012).

This investigation reports that the Slate-throated Redstart had a significantly higher mean FID at the busiest trail – Chirripó – when compared with other trails. This would suggest that the species has become sensitised to the high level of daily anthropogenic disturbance on the trail. The likely reason for this is that the Chirripó trail is constantly used by porters and their horses who traverse the trail at much higher speeds and with much more noise than hikers alone. This creates the random, unpredictable stimulus necessary for sensitisation. Similarly, sensitisation may also have occurred to the Black Guan as it too demonstrated highest FID at the busiest trails although results for this species were not reported significant between trails. However, as the Black Guan is listed Near Threatened on the IUCN Red List, further investigations should be considered. Conversely,

the FID of the Common Chlorospingus, while not statistically significant, was shortest at Chirripó. This may be indicative of habituation and an adaptation by the species to the daily disturbances along the trail, although FID for this species was only marginally different between trails indicating that any effect from disturbance may be negligible.

8.2 BODY LENGTH AND FLIGHT INITIATION DISTANCE

Longer FID are usually associated with longer birds with a larger body mass for a number of different reasons. Firstly, larger birds are usually more detectable to predators than smaller species and so to counter this they initiate flight earlier (Weston *et al.*, 2012). Secondly, larger species can oftentimes possess less aerodynamic abilities than their smaller counterparts and may need additional space and time to successfully escape (Fernández-Juricic *et al.*, 2002). Thirdly, smaller birds have relatively higher metabolic requirements which may cause them to incur the risk of foraging for longer periods before finally taking flight (Tätte *et al.*, 2018). Finally, larger birds have larger eyes which facilitate earlier predator detection (Møller & Erritzøe, 2010). However, this study did not identify a positive correlation between body length and FID as was expected. Instead, it reports that birds with the shortest mean body length are found at trails with the longest mean FID, such as Chirripó, Río and Montaña. The inverse is also true, as the shortest mean FID are present at trails where the birds have the longest mean body length - Gavilán, Heliconia and Principal.

One of the most likely explanations for this unexpected occurrence is the difference in habitats around the trails. While being the busiest trail, Chirripó is also the only trail that has sections lying adjacent to pasture land that often contain a small group of cattle. This may explain the short mean body length due to the fact that populations of larger birds often vacate agricultural areas as they tend to be more adversely affected by farmland than do smaller birds (Concepción & Díaz, 2011). Chirripó is also the only trail where data was collected from sections of old growth forest which consist of older, taller trees and a less dense lower canopy. The trail at Chirripó was also wider in some parts than others and many sections were more open with less enclosed vegetation. A "perceived risk often increases from refugia such as ….. trees, as reflected by an increase in flight initiation distance" (Camp *et al.*, 2012). Therefore, it is possible that Chirripó reported the highest mean FID yet the shortest mean body lengths because birds take flight earlier as their distance from vegetation increases. Additionally, it is also possible that this openness at Chirripó improved visibility thus increasing the distance at which the bird could detect the surveyor, resulting in longer FID (Whittingham *et al.*, 2004).

The Río trail was the only one located adjacent a very loud, fast-flowing river which reduced the ability of the surveyor to hear birds and therefore possibly skewing data. This may explain why Río had a high mean FID, but low mean body length because larger birds, such as the Black Guan, tended to make few, if any, vocalisations

so were usually only detected by the noise they produced when moving in the undergrowth. Gavilán and Heliconia trails reported lower FID yet the highest mean species body length. Both these trails were the most enclosed with the densest vegetation. They were also only used occasionally by researchers, meaning that birds were not likely to be accustomed to human disturbance and early detection of the surveyor was less probable. Gavilán was also the only trail with sections of naturally regenerated forest of more than thirty years old which may also have influenced the results.

8.3 SPECIES ABUNDANCE AND DIVERSITY

Several trails showed clear trends with regards to abundance and diversity, and the results are likely due to a combination of habitat differences and level of anthropogenic disturbance. The trail that sees the most use and disturbance by humans, Chirripó, reported the highest abundance of birds yet one of the lowest diversity values. As previously discussed, this trail is wider and more open, increasing the surveyor's ability to spot birds which may account for the high numbers of birds recorded per survey. The low diversity value however is possibly a negative effect of the high levels of disturbance from recreationists and the adjoining farmland. Insectivores, such as the Common Chlorospingus and the Slate-throated Redstart, were recorded relatively less often at Chirripó compared with frugivores such as the Ruddy-capped Nightingale-Thrush (*Catharus frantzii*) or Northern Emerald Toucanet (*Aulacorhynchus prasinus*). In the Cordóba Mountains of Argentina, reduced avian insectivore density at trails was reported and was speculated to be because of reduced invertebrate numbers present at trails due to constant human disturbance (Heil *et al.*, 2006). Indeed, Gomes *et al.* (2008) concluded that "throughout the Neotropics, tolerance of frugivorous birds to habitat disturbance is a frequently seen phenomenon".

This research project reported that Principal and Río, both trails of medium levels of anthropogenic activity, possessed the highest levels of diversity, but some of the lowest species abundance figures. High levels of diversity may be due to the relatively low elevation of both trails as species richness and diversity decreases with altitude (Doumenge *et al.*, 1995). Gavilán possessed the lowest diversity and second lowest abundance values. Reasons for this could, again, be related to habitat as this trail was the only one to have some sections of naturally regenerated forest of more than thirty years. The older and taller trees, along with the enclosed nature of the vegetation, made observations and correct identification more difficult. The relatively high elevation of the trail may be the cause of the low species diversity values for reasons described above.

8.4 FUTURE STUDIES

The significant difference of the FID of the Slate-throated Redstart at Chirripó when compared with the other five trails should warrant further investigation. Data collection for this study was undertaken over a relatively short period of time and on only five occasions from the Chirripó trail. Therefore, it is to be recommended that further studies are carried out over a longer period with larger amounts of raw data being collected for analysis. Additionally, this project was carried out during the rainy season when the numbers of people using the recreational trails is lower, therefore data collection during the months of peak trail-use would be beneficial. It is also recommended that FID data is collected throughout the year to take into account the possibility of longer distances elicited by "naïve juveniles" after fledging (Legagneux & Ducatez, 2013). It is also suggested that in any future studies, body mass rather than body length should be compared because some species, such as the Slate-throated Redstart, have relatively long tails which can skew comparative results. For example, the Common Chlorospingus is 13.5 cm long with a body mass of 20 g, while the Slate-throated Redstart is 12 cm in length but with a body mass of only 9 g (Stiles & Skutch, 1989).

9 CONCLUSION

The extensive trail network in the area is utilised by recreationists and researchers alike, with both parties valuing local bird populations. While appearing relatively benign when compared with other outdoor activities such as hunting, horse-riding or skiing, the use of trails for research or hiking can significantly alter the FID of some bird species as demonstrated by this project. The higher FID of the Slate-throated Redstart at the Chirripó trail is the first indication that unfettered human use of the trails may have serious ramifications to local wildlife. Further long-term studies on the Slate-throated Redstart will be necessary to ascertain if local populations are affected, but the results obtained provide baseline data from which to draw upon.

Intensive use of the Chirripó trail appears to have decreased the tolerance of the Slate-throated Redstart to human disturbance, making them warier and more fearful. The behavioural consequences of this disturbance to birds can be profound. It may potentially affect their strict energy budgets, curtailing time engaged in behaviours such as foraging, mating and nesting, which can ultimately lead to fitness reduction and decreased reproductive success (Bechét *et al.*, 2004). As outdoor recreational activities and the ecotourism industry itself both increase in popularity, the potential for human interaction and disturbance to avifauna becomes ever greater. Mitigation and management of this disturbance will be successful only when enough relevant data provides policymakers with the knowledge to devise strategies and plans, thereby making the results garnered from this project potentially extremely valuable.

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APPENDIX I. WEATHER CLASSES

TABLE A-1 – RAIN CLASS

Rain Class		Conditions
0	None	No rain.
1	Drizzle	Barely raining. Tiny raindrops, very sparse or erratic rainfall. Rain gear not necessary.
2	Light	Rain falling at a steady rate, but sparse. Would get soaked if out for an extended period without rain gear.
3	Moderate	Rain constant and dense. Would get soaked in minutes without rain gear.
4	Heavy	Raindrops large and falling with force. Streams forming on some trails. Would get soaked immediately without rain gear.
5	Severe	Storm conditions. Sheets of rain falling from the sky. Trails become creeks. Dangerous to be out at all.

TABLE A-2 - WIND CLASS

Wind Class		Conditions
0	Calm	Calm. Smoke rises vertically.
1	Faint	Fog and smoke drift indicates wind direction. Leaves stationary.
2	Light	Wind felt on exposed skin. Leaves rustle.
3	Moderate	Leaves and small twigs constantly moving. Light flags extended.
		Dust and loose paper raised. Small branches begin to move.
4	Strong	Branches of a moderate size move. Small trees in leaf begin to sway.
		Large branches in motion. Umbrella use becomes difficult. Empty plastic bins tip over.
5	Severe	Whole trees in motion. Effort needed to walk against the wind.

TABLE A-3 – CLOUD COVER CLASS

Cloud Class		Conditions
0	Clear	No clouds.
1	Mostly Clear	A few scattered clouds.
2	Partly Cloudy	An equal amount of clouds and clear sky.
3	Mostly Cloudy	More clouds than clear sky.
4	Overcast	Full cloud cover.
5	Misty	Low lying clouds (fog).

APPENDIX II. RAW DATA

Survey ID	Date	Start Time	End Time	Rain	Wind	Cloud	Trail	Category	Species		FID (m)
1	21-May	06:00	07:50	0	2	1	Rio	Medium	Common Chlorospingus	*Chlorospingus flavopectus*	13.3
1	21-May	06:00	07:50	0	2	1	Rio	Medium	White-throated Mountain-Gem	*Lampornis castaneoventris*	9.5
2	21-May	08:00	09:20	0	1	0	Principal	Medium	Common Chlorospingus	*Chlorospingus flavopectus*	4.8
2	21-May	08:00	09:20	0	1	0	Principal	Medium	Common Chlorospingus	*Chlorospingus flavopectus*	4.4
2	21-May	08:00	09:20	0	1	0	Principal	Medium	Common Chlorospingus	*Chlorospingus flavopectus*	7.2
2	21-May	08:00	09:20	0	1	0	Principal	Medium	Common Chlorospingus	*Chlorospingus flavopectus*	5.7
2	21-May	08:00	09:20	0	1	0	Principal	Medium	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	6.1
3	22-May	06:30	07:40	2	1	4	Montana	Medium	Black-Cheeked Warbler	*Basileuterus melanogenys*	5
3	22-May	06:30	07:40	2	1	4	Montana	Medium	Black-Cheeked Warbler	*Basileuterus melanogenys*	7.4
3	22-May	06:30	07:40	2	1	4	Montana	Medium	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	16.3
3	22-May	06:30	07:40	2	1	4	Montana	Medium	Scintillant Hummingbird	*Selasphorus scintilla*	4
4	22-May	08:50	07:40	0	1	2	Heliconia	Low	Slate-throated Redstart	*Myioborus miniatus*	8.9
5	23-May	05:45	08:00	0	0	1	Gavilán	Low	Common Chlorospingus	*Chlorospingus flavopectus*	7.2
5	23-May	05:45	08:00	0	0	1	Gavilán	Low	Slate-throated Redstart	*Myioborus miniatus*	5
5	23-May	05:45	08:00	0	0	1	Gavilán	Low	Violet Sabrewing	*Campylopterus hemileucurus*	14.2
6	23-May	08:30	09:10	0	0	3	Montana	Medium	Emerald Toucanet	*Aulacorhynchus prasinus*	6
7	24-May	05:45	06:50	0	0	1	Montana	Medium	No observations		
8	24-May	07:00	09:10	0	0	1	Chirripo	High	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	6.5
8	24-May	07:00	09:10	0	0	1	Chirripo	High	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	4.8
8	24-May	07:00	09:10	0	0	1	Chirripo	High	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	7.4
8	24-May	07:00	09:10	0	0	1	Chirripo	High	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	10.6
8	24-May	07:00	09:10	0	0	1	Chirripo	High	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	10
8	24-May	07:00	09:10	0	0	1	Chirripo	High	Slate-throated Redstart	*Myioborus miniatus*	19.1
9	25-May	05:55	06:45	0	1	1	Principal	Medium	Black Guan	*Chamaepetes unicolor*	13.1
9	25-May	05:55	06:45	0	1	1	Principal	Medium	Large-Footed Finch	*Pezopetes capitalis*	7.1
9	25-May	05:55	06:45	0	1	1	Principal	Medium	Slate-throated Redstart	*Myioborus miniatus*	6.1
9	25-May	05:55	06:45	0	1	1	Principal	Medium	Slate-throated Redstart	*Myioborus miniatus*	6.7
10	25-May	07:20	08:55	0	0	2	Rio	Medium	Common Chlorospingus	*Chlorospingus flavopectus*	5.7
10	25-May	07:20	08:55	0	0	2	Rio	Medium	Scintillant Hummingbird	*Selasphorus scintilla*	3.8
10	25-May	07:20	08:55	0	0	2	Rio	Medium	Sulphur-Winged Parakeet	*Pyrrhura hoffmanni*	15.3
11	25-May	09:00	09:35	0	0	1	Principal	Medium	Slate-throated Redstart	*Myioborus miniatus*	10
12	28-May	06:00	07:15	0	0	3	Montana	Medium	Flame-coloured Tanager	*Piranga bidentata*	5
12	28-May	06:00	07:15	0	0	3	Montana	Medium	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	7.8
12	28-May	06:00	07:15	0	0	3	Montana	Medium	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	7.6
12	28-May	06:00	07:15	0	0	3	Montana	Medium	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	4.6
13	28-May	07:25	08:05	0	1	4	Principal	Medium	No observations		
14	29-May	06:15	08:10	0	0	1	Chirripo	High	Clay-coloured Thrush	*Turdus grayi*	10.8
14	29-May	06:15	08:10	0	0	1	Chirripo	High	Common Chlorospingus	*Chlorospingus flavopectus*	5.7
14	29-May	06:15	08:10	0	0	1	Chirripo	High	Flame-coloured Tanager	*Piranga bidentata*	16.5
14	29-May	06:15	08:10	0	0	1	Chirripo	High	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	11
14	29-May	06:15	08:10	0	0	1	Chirripo	High	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	13.8
14	29-May	06:15	08:10	0	0	1	Chirripo	High	Spotted Woodcreeper	*Xiphorhynchus erythropygius*	7.4
14	29-May	06:15	08:10	0	0	1	Chirripo	High	Tufted Flycatcher	*Mitrephanes phaeocercus*	10.1
15	29-May	08:50	09:20	0	1	1	Gavilán	Low	Slate-throated Redstart	*Myioborus miniatus*	5.5
15	29-May	08:50	09:20	0	1	1	Gavilán	Low	White-throated Mountain-Gem	*Lampornis castaneoventris*	4.2
16	29-May	09:25	10:15	0	0	1	Heliconia	Low	No observations		
17	01-Jun	06:10	08:15	0	1	3	Montana	Medium	Common Chlorospingus	*Chlorospingus flavopectus*	5.3
17	01-Jun	06:10	08:15	0	1	3	Montana	Medium	Common Chlorospingus	*Chlorospingus flavopectus*	7.6

Survey ID	Date	Start Time	End Time	Rain	Wind	Cloud	Trail	Category	Species		FID (m)
17	01-Jun	06:10	08:15	0	1	3	Montana	Medium	Common Chlorospingus	*Chlorospingus flavopectus*	7.6
17	01-Jun	06:10	08:15	0	1	3	Montana	Medium	Common Chlorospingus	*Chlorospingus flavopectus*	7.2
17	01-Jun	06:10	08:15	0	1	3	Montana	Medium	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	7
17	01-Jun	06:10	08:15	0	1	3	Montana	Medium	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	8.4
17	01-Jun	06:10	08:15	0	1	3	Montana	Medium	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	7.2
17	01-Jun	06:10	08:15	0	1	3	Montana	Medium	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	8.4
17	01-Jun	06:10	08:15	0	1	3	Montana	Medium	Slate-throated Redstart	*Myioborus miniatus*	9.5
17	01-Jun	06:10	08:15	0	1	3	Montana	Medium	Violet Sabrewing	*Campylopterus hemileucurus*	18.9
17	01-Jun	06:10	08:15	0	1	3	Montana	Medium	Yellow-Thighed Finch	*Pselliophorus tibialis*	4.8
18	01-Jun	08:30	09:10	0	0	3	Principal	Medium	Common Chlorospingus	*Chlorospingus flavopectus*	7.8
19	04-Jun	06:10	07:00	0	2	1	Rio	Medium	Black Guan	*Chamaepetes unicolor*	7.8
19	04-Jun	06:10	07:00	0	2	1	Rio	Medium	Black Guan	*Chamaepetes unicolor*	13.5
20	04-Jun	07:05	08:55	0	2	1	Gavilán	Low	Black Guan	*Chamaepetes unicolor*	6.8
20	04-Jun	07:05	08:55	0	2	1	Gavilán	Low	Common Chlorospingus	*Chlorospingus flavopectus*	5.3
20	04-Jun	07:05	08:55	0	2	1	Gavilán	Low	Common Chlorospingus	*Chlorospingus flavopectus*	7
20	04-Jun	07:05	08:55	0	2	1	Gavilán	Low	Common Chlorospingus	*Chlorospingus flavopectus*	4
20	04-Jun	07:05	08:55	0	2	1	Gavilán	Low	Common Chlorospingus	*Chlorospingus flavopectus*	7.2
20	04-Jun	07:05	08:55	0	2	1	Gavilán	Low	Violet Sabrewing	*Campylopterus hemileucurus*	10.6
21	04-Jun	09:00	09:45	0	0	4	Heliconia	Low	Black Guan	*Chamaepetes unicolor*	9.7
21	04-Jun	09:00	09:45	0	0	4	Heliconia	Low	Common Chlorospingus	*Chlorospingus flavopectus*	7.8
22	06-Jun	06:00	06:30	0	0	2	Principal	Medium	Sulphur-Winged Parakeet	*Pyrrhura hoffmanni*	5
23	06-Jun	06:35	07:35	0	0	1	Rio	Medium	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	8
23	06-Jun	06:35	07:35	0	0	1	Rio	Medium	Slate-throated Redstart	*Myioborus miniatus*	7
23	06-Jun	06:35	07:35	0	0	1	Rio	Medium	Slate-throated Redstart	*Myioborus miniatus*	9.1
24	06-Jun	07:45	08:30	0	0	3	Heliconia	Low	No observations		
25	08-Jun	06:25	08:30	0	0	3	Chirripo	High	Black Guan	*Chamaepetes unicolor*	9.8
25	08-Jun	06:25	08:30	0	0	3	Chirripo	High	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	5.3
26	08-Jun	08:40	09:50	0	0	4	Gavilán	Low	No observations		
27	12-Jun	07:00	07:50	2	0	4	Principal	Medium	Black Guan	*Chamaepetes unicolor*	10.8
27	12-Jun	07:00	07:50	2	0	4	Principal	Medium	Black Guan	*Chamaepetes unicolor*	8.7
28	12-Jun	07:55	09:05	2	0	4	Rio	Medium	Emerald Toucanet	*Aulacorhynchus prasinus*	12.5
28	12-Jun	07:55	09:05	2	0	4	Rio	Medium	Slate-throated Redstart	*Myioborus miniatus*	6.7
28	12-Jun	07:55	09:05	2	0	4	Rio	Medium	Slate-throated Redstart	*Myioborus miniatus*	7.2
28	12-Jun	07:55	09:05	2	0	4	Rio	Medium	Violet Sabrewing	*Campylopterus hemileucurus*	6.7
29	12-Jun	09:30	10:00	0	0	5	Heliconia	Low	Black Guan	*Chamaepetes unicolor*	5.3
29	12-Jun	09:30	10:00	0	0	5	Heliconia	Low	Slate-throated Redstart	*Myioborus miniatus*	8.2
29	12-Jun	09:30	10:00	0	0	5	Heliconia	Low	Spotted Woodcreeper	*Xiphorhynchus erythropygius*	7.6
30	13-Jun	09:00	09:25	0	0	1	Heliconia	Low	Black Guan	*Chamaepetes unicolor*	5.7
30	13-Jun	09:00	09:25	0	0	1	Heliconia	Low	Black Guan	*Chamaepetes unicolor*	4.9
30	13-Jun	09:00	09:25	0	0	1	Heliconia	Low	Black Guan	*Chamaepetes unicolor*	8.7
31	13-Jun	09:25	10:15	0	0	1	Gavilán	Low	Common Chlorospingus	*Chlorospingus flavopectus*	5.1
31	13-Jun	09:25	10:15	0	0	1	Gavilán	Low	Slate-throated Redstart	*Myioborus miniatus*	4.7
31	13-Jun	09:25	10:15	0	0	1	Gavilán	Low	Slate-throated Redstart	*Myioborus miniatus*	4.7
32	14-Jun	07:35	09:20	0	0	2	Chirripo	High	Emerald Toucanet	*Aulacorhynchus prasinus*	6.8
32	14-Jun	07:35	09:20	0	0	2	Chirripo	High	Emerald Toucanet	*Aulacorhynchus prasinus*	8.3
32	14-Jun	07:35	09:20	0	0	2	Chirripo	High	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	4.7
32	14-Jun	07:35	09:20	0	0	2	Chirripo	High	Silver-throated Tanager	*Tangara icterocephala*	5.6
32	14-Jun	07:35	09:20	0	0	2	Chirripo	High	Slate-throated Redstart	*Myioborus miniatus*	15.1
32	14-Jun	07:35	09:20	0	0	2	Chirripo	High	Slate-throated Redstart	*Myioborus miniatus*	11.1
33	14-Jun	09:45	10:10	0	0	4	Gavilán	Low	No observations		
34	15-Jun	08:00	08:30	0	0	1	Principal	Medium	No observations		

Survey ID	Date	Start Time	End Time	Rain	Wind	Cloud	Trail	Category	Species		FID (m)
35	15-Jun	08:45	09:45	0	0	1	Montana	Medium	Black Guan	*Chamaepetes unicolor*	9
35	15-Jun	08:45	09:45	0	0	1	Montana	Medium	Emerald Toucanet	*Aulacorhynchus prasinus*	5.6
35	15-Jun	08:45	09:45	0	0	1	Montana	Medium	Red-headed Barbet	*Eubucco bourcierii*	4.9
35	15-Jun	08:45	09:45	0	0	1	Montana	Medium	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	6.4
36	15-Jun	09:45	10:15	0	0	1	Principal	Medium	No observations		
37	19-Jun	07:40	08:15	0	0	4	Principal	Medium	Emerald Toucanet	*Aulacorhynchus prasinus*	5.3
37	19-Jun	07:40	08:15	0	0	4	Principal	Medium	Yellow-faced Grassquit	*Tiaris olivaceus*	11.5
38	19-Jun	08:15	09:15	0	0	3	Rio	Medium	Common Chlorospingus	*Chlorospingus flavopectus*	5.8
39	19-Jun	09:20	09:55	0	1	3	Heliconia	Low	Great Kiskadee	*Pitangus sulphuratus*	9.6
40	20-Jun	09:00	09:55	0	0	3	Gavilán	Low	Yellow-thighed Finch	*Pselliophorus tibialis*	3.6
41	21-Jun	06:55	08:30	0	0	0	Chirripo	High	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	4
41	21-Jun	06:55	08:30	0	0	0	Chirripo	High	Rufous-collared Sparrow	*Zonotrichia capensis*	3.6
41	21-Jun	06:55	08:30	0	0	0	Chirripo	High	Yellow-faced Grassquit	*Tiaris olivaceus*	4.9
41	21-Jun	06:55	08:30	0	0	0	Chirripo	High	Yellow-faced Grassquit	*Tiaris olivaceus*	3.8
42	21-Jun	08:55	09:40	0	0	1	Montana	Medium	No observations		
43	25-Jun	07:10	08:00	0	1	3	Principal	Medium	Emerald Toucanet	*Aulacorhynchus prasinus*	4.7
43	25-Jun	07:10	08:00	0	1	3	Principal	Medium	Emerald Toucanet	*Aulacorhynchus prasinus*	7.7
43	25-Jun	07:10	08:00	0	1	3	Principal	Medium	Scintillant Hummingbird	*Selasphorus scintilla*	3
43	25-Jun	07:10	08:00	0	1	3	Principal	Medium	Sooty Thrush	*Turdus nigrescens*	9.8
44	25-Jun	08:00	08:50	0	0	5	Rio	Medium	Common Chlorospingus	*Chlorospingus flavopectus*	3.6
44	25-Jun	08:00	08:50	0	0	5	Rio	Medium	Spotted Woodcreeper	*Xiphorhynchus erythropygius*	6.2
45	25-Jun	08:55	09:35	0	0	3	Gavilán	Low	Ruddy Pigeon	*Patagioenas subvinacea*	7.7
46	25-Jun	09:35	10:00	0	1	3	Heliconia	Low	Common Chlorospingus	*Chlorospingus flavopectus*	7.3
46	25-Jun	09:35	10:00	0	1	3	Heliconia	Low	Silver-throated Tanager	*Tangara icterocephala*	3.8
47	28-Jun	05:45	06:25	0	1	2	Principal	Medium	Black Guan	*Chamaepetes unicolor*	4.3
47	28-Jun	05:45	06:25	0	1	2	Principal	Medium	Black Guan	*Chamaepetes unicolor*	4.7
47	28-Jun	05:45	06:25	0	1	2	Principal	Medium	Chiriqui Quail-dove	*Geotrygon chiriquensis*	3.8
48	28-Jun	06:30	07:35	0	2	2	Montana	Medium	Clay-coloured Thrush	*Turdus grayi*	11.3
48	28-Jun	06:30	07:35	0	2	2	Montana	Medium	Common Chlorospingus	*Chlorospingus flavopectus*	7
48	28-Jun	06:30	07:35	0	2	2	Montana	Medium	Ruddy-capped Nightingale-thrush	*Catharus frantzii*	9.6
48	28-Jun	06:30	07:35	0	2	2	Montana	Medium	Violet Sabrewing	*Campylopterus hemileucurus*	5.8
48	28-Jun	06:30	07:35	0	2	2	Montana	Medium	Yellow-thighed Finch	*Pselliophorus tibialis*	11.9

APPENDIX III. RESULTS IN TAXONOMIC ORDER

List of 25 unique bird species observed arranged in taxonomic order following Garrigues & Dean (2017). Species in bold are endemic to Costa Rica and western Panama.

			Chirripó	Gavilan	Heliconia	Montana	Principal	Río	Total
Black Guan	***Chamaepetes unicolor***		1	1	5	1	5	2	15
Violet Sabrewing	*Campylopterus hemileucurus*			2		2		1	5
White-throated Mountain Gem	***Lampornis castaneoventris***			1				1	2
Scintillant Hummingbird	***Selasphorus scintilla***					1	1	1	3
Ruddy Pigeon	*Patagioenas subvinacea*			1					1
Chiriqui Quail-Dove	***Geotrygon chiriquensis***						1		1
Sulphur-winged Parakeet	***Pyrrhura hoffmanni***						1	1	2
Red-headed Barbet	*Eubucco bourcierii*					1			1
Emerald Toucanet	*Aulacorhynchus prasinus*		2			2	3	1	8
Spotted Woodcreeper	*Xiphorhynchus erythropygius*		1		1			1	3
Tufted Flycatcher	*Mitrephanes phaeocercus*		1						1
Great Kiskadee	*Pitangus sulphuratus*				1				1
Ruddy-capped Nightingale-Thrush	*Catharus frantzii*		10			10	1	1	22
Sooty Thrush	***Turdus nigrescens***						1		1
Clay-coloured Thrush	*Turdus grayi*		1			1			2
Slate-throated Redstart	*Myioborus miniatus*		3	4	2	1	3	4	17
Black-cheeked Warbler	***Basileuterus melanogenys***					2			2
Silver-throated Tanager	*Tangara icterocephala*		1		1				2
Yellow-faced Grassquit	*Tiaris olivaceus*		2				1		3
Yellow-thighed Finch	***Pselliophorus tibialis***			1		2			3
Large-footed Finch	***Pezopetes capitalis***						1		1
Common Chlorospingus	*Chlorospingus flavopectus*		1	6	2	5	5	4	23
Rufous-collared Sparrow	*Zonotrichia capensis*		1						1
Flame-coloured Tanager	*Piranga bidentata*		1			1			2